§11. The Effect of Magnetic Configuration on the Particle Pinch Velocity

Iguchi, H., Ida, K., Yamada, H., Itoh, K.,
Itoh, S.-I. (Kyushu Univ.)
Matsuoka, K., Okamura, S., Sanuki, H., Yamada, I.
Takenaga, H., Uchino, K., Muraoka, K. (Kyushu Univ.)

In the neutral beam heated plasmas, the peaked density profiles have been observed with magnetic axis shifted inward, while the flattened density profiles are observed with magnetic axis shifted outward. This phenomenon is considered to be linked with the diffence in particle transport processes. Particle transport coefficients such as diffusivity and pinch velocity are evaluated ar r/a = 0.7 for the two different magnetic configurations, based on the detailed measurements of atomic hydrogen density distributions as shown in the previous section. Table 1 shows the comparison of these parameters for the two cases together with related physical quantities.

In the case $R_{ax} = 92.1$ cm, inward pinch is obtained with the velocity $V_{in} = 2$ m/s, while diffusivity $D = 0.4$ m^2/s. On the other hand, in the case $R_{ax} = 99.5$ cm, the density gradient is positive in the region of $0.4 < r/a < 0.8$. It shows that there is a non-diffusive outward particle flux. The flow velocity is calculated to be $V_{in} = -4$ m/s, using the data of $\Gamma = 6 \times 10^{19}$ $m^{-2}s^{-1}$ and $n_e = 2.4 \times 10^{19}$ cm^{-3}, where $D = 0.4$ m^2/s is assumed.

The neoclassical prediction of particle flux is much smaller than the experimental observation, which suggests that the observed particle flux is dominated by the anomalous transport.[1] According to the pinch theory (Hazeltine et al 1981, Itoh 1990), the particle flow is expressed as

$$\Gamma = -Dn\left[\frac{\nabla n}{n} + \alpha\frac{\nabla T}{T} - \left(\frac{eE_r}{T} - \left\langle\frac{r\omega}{m}\right\rangle\frac{eB}{cT}\right)\right]$$

where D is positive definite. The numerical factor α is of the order of unity and $\langle r\omega/m\rangle$ is the average phase velocity of the turbulence. In this model the pinch term can change its sign when (1) $\alpha T'$ changes sign or (2) $[eE_r/T - \langle r\omega/m\rangle eB/cT]$ changes sign. From the comparison in Table 1, fluctuations with their characters dependent on the magnetic configuaration are the possible candidate to explain the results, which remain for future study.

It is also found that both pinch velocity and diffusivity in CHS are roughly proportional to B^{-1}. In tokamaks, however, those quantities are scaled as I_p^{-1} rather than B^{-1}, suggesting an intrinsic difference of the anomalous transport in these two devices.

The effect of this convective flow on the energy confinement is discussed. The energy loss rate is evaluated at r/a = 0.7 for $R_{ax} = 99.5$ cm as (5/2) $nTV_{in} = 120$ s^{-1}, where the change of flow velocity from 2 m/s to - 4 m/s is taken into account. The total energy loss rate at r/a = 0.7 is calculated to be 1,000 s^{-1} from the thermal energy confinement time of 1 ms at this radius, which is evaluated using PROCTR-MOD. The convective loss contributes roughly 10 % of the total energy loss. This is consistent with the fact that the energy confinement time is shorter than the particle confinement time by an order of magnitude at this radius.

Table 1

	Rax = 92.1 cm	Rax = 99.5 cm
Density Profile	Peaked	Flattened
D	0.4 m^2/s	----------
V_{in}	2 m/s	- 4 m/s
T_e'/T_e	18 m^{-1}	16 m^{-1}
E_r	Negative ($\lvert E_r\rvert<5$ kV/m)	Negative ($\lvert E_r\rvert<5$ kV/m)

Reference

1) Iguchi, H., Ida, K., Yamada, H., Itoh, K., Itoh, S.-I., Matsuoka, K., Okamura, S. Sanuki, H., Yamada, I., Takenaga, H., Uchino, K. Muraoka, K.; to be published in Plasma Phys. and Controlled Fusion.